Craniocaudal Extension as an Indication of Surgical Outcome in Transsphenoidal Surgery for Pituitary Adenomas

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Abstract Transsphenoidal approach is considered the treatment of choice for pituitary adenoma removal. Suprasellar extension is regarded a drawback for complete removal of these tumors through this approach. Evaluate the correlation between the preoperative radiologic craniocaudal extension on MRI of pituitary adenomas and the extent of tumor removal. A retrospective study. Tertiary care hospital. 560 patients underwent transsphenoidal removal of pituitary adenomas. The degree of removal of pituitary tumor in the follow-up imaging of the patients was correlated with the preoperative extension in mid-Coronal T1 W Gd. Tumors with suprasellar extension can be classified into: Type I tumors with extension confined to

the sellar boundaries, resulted in complete removal in all cases (100%), type II tumors with suprasellar extension reaching the floor of the 3rd ventricle, resulted in complete removal in 70.2% of the cases, type III tumors with suprasellar extension above the 3rd ventricle, had only 13.5% of complete removal. Integration of radiologic findings into a scheme for the preoperative determination of possibility of total removal of the tumor through transsphenoidal approach, can give better correlation to the surgical outcome of pituitary tumors.

Keywords Transsphenoidal pituitary surgery · Pituitary adenomas · Surgical outcome · Radioanatomical classification

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Abbreviations

WHO World Health Organization
H–W Hardy–Wilson classification
TSA Transsphenoidal adenomectomy

Introduction

Pituitary adenomas are a diverse group of tumors arising from the pituitary gland. They display an array of hormonal and proliferative behaviors. They may be small, slowly growing and hormonally inactive, or they may grow rapidly, producing symptoms of an intracranial mass [1, 2]. Numerous attempts were made to classify pituitary adenomas [3]. Pituitary tumors were clinically differentiated on the basis of their size and hormonal secretion.

The most widely used radioanatomical classification, proposed by Hardy in the 1970s, was based primarily on

skull X-rays, pneumoencephalography, polytomography, and carotid angiography as the available imaging tools for the transcranial access [4–6]. It divides pituitary tumors according to size into microadenomas (the greatest diameter is <10 mm) and macroadenomas (the greatest diameter is ≥ 10 mm) [4, 6–8]. Subsequently this has been validated by the application of magnetic resonance imaging (MRI) and computed tomography. This classification places adenomas into one of four grades (I–IV) according to the extension within the sella turcica. It also addresses the suprasellar and parasellar extensions (A–E) [4, 6, 9].

The five-tier WHO classification of adenohypophyseal neoplasms, takes into consideration the clinical and laboratory findings, imaging results, histological, immunocytochemical and ultrastructural features of tumor cells [1, 3, 7, 10]. It basically aims at determination of the prognosis of such a complex heterogeneous group of tumors. In this classification, information derived from neuroimaging and operative data constitute level 2 [3, 10].

Consideration of size, extension and invasiveness are imperative in preoperative surgical decision making [10]. Although generally considered benign, pituitary adenomas can have considerable compressive mass effects and endocrine manifestations with serious morbidity [8]. The goals of surgery are to eliminate mass effect and normalize hormonal hypersecretion with minimal morbidity [11].

The transsphenoidal microsurgical approach to the pituitary has been established as the most widely employed surgical approach and represents a major development in the safe surgical treatment [5]. This approach is often successful in accessing all tumors and achieving the main surgical goals. However, complete removal is not always possible in the presence of suprasellar and parasellar extensions.

Technologic advances especially in CT scan and MRI have made possible an exact preoperative evaluation of the extent of the pituitary tumors. This dictates the integration of these radiologic findings into a scheme for the preoperative determination of possibility of total removal of the tumor. A new classification is needed to suit the different approach and the advances in radiologic evaluation giving better correlation to the surgical outcome and prognosis.

We conducted this study in order to evaluate the outcome of transsphenoidal approach regarding the completeness of tumor removal in suprasellar extension of pituitary adenomas. We retrospectively reviewed our series of TSA to evaluate the degree of surgical removal in relation to the suprasellar extension. We then tried to formulate some modifications in the H–W classification based on the results of our series. This was based on radiographic assessment that correlates with operative findings and extent of removal through the transsphenoidal approach.

Materials and Methods

Patients diagnosed with pituitary adenomas in the period from February 2004 to September 2009 were included in our study. They were 560 cases (328 females and 232 males). Their age ranged from 16 to 65 years old (average = 31). All patients underwent transsphenoidal microscopic approach for removal of the tumors with a combined team of Otolaryngologists and Neurosurgeons. As we were beginning to use endoscope during the study period, endoscopic assistance was used in some patients, using 0° and 30° endoscopes, after removing of the main bulk of the tumor microscopically. This allowed removal of residues around the angles, anteriorly, superiorly and laterally. However, we did not look for the value of use endoscope in our results. A followed-up MRI was done in 507 cases (90.66%) at least 3 months after the operation. The follow-up period ranged from 3 months to 5 years (average = 42 months). The main presentations of the patients were headache (61.7%), infertility or amenorrhea galactorrhea (37.3%), visual defects (18.3%), increase intracranial pressure (4%), apoplexy (2.3%), acromegaly (7.3%) and Cushing's disease (1.3%).

Radiological evaluation was used to measure the extent of surgical removal of pituitary adenomas in this cohort of patients. The degree of removal of pituitary tumor as seen in the follow-up imaging of the patients was correlated with the preoperative craniocaudal extension of the tumor in mid-Coronal T1 W Gd sequences.

From these data, we formulated a new classification of pituitary tumors based on radiographic assessment that correlates with operative findings and prognosis.

This classification deals primarily with the vertical extension of the pituitary tumors in relation to the third ventricle as the main determinant of the complete removal of the suprasellar extension of the tumors. This depends on the relationship between the tumor suprasellar size and the feasibility of excision through the transsphenoidal approach.

Statistical analysis was done to compare the outcome between different groups using SPSS version 14.

Results

Based on the H–W classification, we divided the tumors as follows (Fig. 1).

Type I tumors were those related to the sellar boundaries (H–W grade 0–3); type II were tumors with suprasellar extension reaching the floor of the 3rd ventricle (H–W group A and B), while type III were tumors with suprasellar extension above the 3rd ventricle (H–W group C).

Fig. 1 Proposed classification of suprasellar extension of pituitary adenomas

According to our proposed classification, there were 182 (32.6%) type I tumors, 252 (45%) type II tumors and 126 (22.3%) type III tumors. All type I tumors in this series, had no parasellar extensions. Total surgical removal was achieved in 376 patients (67.1%), while incomplete removal was seen in 184 patients (32.9%). For type I tumors, a 100% rate of surgical removal was achieved (Fig. 2). Type II tumors had a 70.2% of complete surgical removal (Fig. 3), while type III had only 13.5% of complete removal (Fig. 4).

In comparing the difference in surgical removal between the 3 groups, there was a statistically significant association between the stage of the tumor and the degree of complete removal (Pearson $\chi^2 = 254.55$ and $P < 0.001$) (Table 1).

Discussion

Significant data regarding tumor size, extension, and invasiveness is of obvious importance in assessing prognosis, in making treatment decisions and in guiding the surgical approach during pituitary surgery. Thirty percent of pituitary tumors escape the confines of the sella and infiltrate surrounding structures with suprasellar or parasellar extensions.

The transsphenoidal approach has evolved into the first-line method of treatment for sellar lesions that offer a minimally invasive approach [12–14]. Recent sophisticated techniques with improvements in radiographic imaging, and biochemical detection of hormonal abnormalities have raised the number of surgical procedures [3, 9]. Advances in the operative microsurgical techniques, magnification and illumination contributed to the resurgence of this approach [12–14].

This shift of the surgical approach from a classical transcranial route resulted into accessing the tumor from below instead from above. This necessitates a shift in viewing, accessing, as well as classification of these tumors. The 2004 novel five-tier WHO integrated and complementary classification, combine several clinico-pathologic aspects including imaging. Nonetheless, it is lacking well-defined pre-operative prognostic radiologic criteria. This classification still uses the grading of the classical H–W radiological classification (I–IV) of pituitary tumors. These grades were basically addressing the most inaccessible parts through a transcranial approach, which is the floor of the sella and extension into the sphenoid sinus [4, 5]. Using a transsphenoid approach, these are the first encountered areas and it should be expected that they are the easiest and most complete parts to be removed through such an access. In our proposed classification we grouped these grades into a type I tumors, which are confined to the sella or sphenoid sinus, and are the first areas to access during the transsphenoid approach. This correlated very well with the complete removal of all tumors in this category via this approach.

Unlike the transcranial route, the main problem encountered with the transsphenoidal approach is the suprasellar extension. However, addressing the suprasellar part is an integral part in relieving the pressure effect of the tumor especially on the optic chiasm. The more the tumor is extending in the suprasellar craniocaudal direction, the

Fig. 2 T1 W MRI pre-and postoperative (left & right) showing type I pituitary adenoma with complete tumor removal

Fig. 3 CT scan sella with contrast pre- and post-operative (left & right) in type II tumors showing some parasellar residual on the left side

Fig. 4 T1 W MRI preoperative (up) and CT scan postoperative (down) of the same patient showing large supra and parasellar residual in type III tumors

more difficult is the complete removal through the transsphenoidal approach.

When the tumor reaches the floor of the 3rd ventricle, i.e., type II tumors, some residue is not uncommonly left behind. However, the surgical goals can effectively be achieved with elimination of the mass effect, symptoms control, with minimal morbidity. Extension above 3rd

Table 1 Results of surgical removal in different groups of pituitary adenomas

	Complete removal	Incomplete removal	Total
Type I	182 100%	0 0%	182
Type II	177 70.2%	75 29.8%	252
Type III	17 13.5%	109 86.5%	126
Total	376	184	560

$\chi^2 = 254.55, P < 0.001$

ventricle, i.e., type III tumors, calls for less than total removal. Significant residue may be left depending whether the diaphragma has been breached or not. However, elimination of the mass effect with decompression is usually achieved, with some symptoms control.

Recently, various management strategies for suprasellar extension has been advocated [15, 16]. Transsphenoidal surgery can be done as an initial treatment followed by a transcranial approach [13, 17]. A second staged transsphenoidal approach can be contemplated if there is descent of the remaining tumor in the sella [18, 19]. Modified and extended endoscopic transsphenoidal approach can be also used [20–22]. One should never also forget other lines of treatment that can still be used successfully and involves medical and radiotherapeutic approaches [11].

With the endoscopes becoming an integral part in TSA, one should expect a better visualization of the different hidden parts of the tumors. This will help a more effective tumor removal [23]. In our series, most of our cases were microscopically operated, and only recently we used the endoscope to assist in tumor removal. Further correlation to the role of endoscope in better tumor removal is still needed.

Some authors correlated the suprasellar tumor volume to the probability of complete removal [24, 25]. They also found that the vertical intracranial extension was the strongest independent predictor of subtotal resection [25]. One should not forget that several other factors, such as blood supply, angiogenesis, and degradation of connective tissue stroma can markedly influence tumor growth, invasiveness and thus surgical removal potential [3]. Most tumors are soft and suckable. However, invasive, vascular and fibrous tumors can limit the surgical removal especially with enlarged size [20, 21]. Prognosis should always be correlated to well-defined criteria of invasion such as MRI, growth rate and clinical follow-up.

Numerous attempts were made to classify pituitary adenomas into distinct entities. The proposed classification is simple and directly matches with transsphenoidal approach as regards operative findings and outcome. This classification can highlight the possibility of complete removal, dictate the proper approach, determine the prognosis and set new definition for the surgical outcome based on radiological and clinical findings. Further progress requires the collaborative efforts of endocrinologists, neurosurgeons, imaging specialists, pathologists and basic scientists [3]. This proposed classification will not only provide pertinent data but will facilitate better preoperative counseling and staging decision.

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